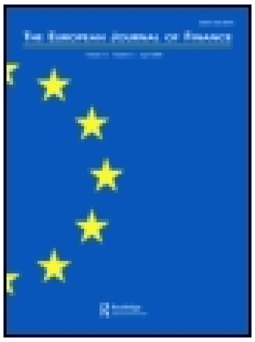

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Bank liquidity and capital shocks in unconventional times

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ABSTRACT
This paper examines bank liquidity management following capital shocks under capital and liquidity regulation in a period of unconventional monetary policies. Studying European banks between 2010 and 2018, we find that bank liquidity is generally not affected by a negative capital shock. Capital shocks are nevertheless transmitted into liquidity positions through balance sheet adjustments. Addressing bank-level balance sheet policies, we find that the banks de-risk assets by replacing corporate loans with financial securities, especially if the shock takes place during periods of heightened central bank interventions. Moreover, asset-side-dominant risk-reducing behavior goes against regulatory intent and indicates that regulatory arbitrage considerations affect banks' responses to shocks. Finally, we document heterogeneous responses by banks depending on their size, type, and country. These findings imply that compliance with regulation may lead to partial shortages in corporate lending, with banks prioritizing investment in government securities in event of a capital shock.

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1. Introduction

The goal of the net stable funding ratio (NSFR) is to foster a stable financial system by preventing excessive maturity mismatching between short-term liabilities and long-term assets (Tirole 2011; Walther 2016). Reflecting macro prudential concerns, the NSFR complements banks' capital requirements and ensures financial stability through more robust liquidity management in the medium term. Introduced in 2010 in the aftermath of the global financial crisis of 2007–2008 (BCBS 2014, 2015), the NSFR standards immediately received attention from ratings agencies, investors, regulators, and central banks, thereby impacting banks' actions even before they came fully into force (Bucalossi et al. 2016).[1,2]

The period following the publication of the NSFR was also characterized by several policy interventions that greatly affected both banks and non-financial firms (e.g. Ricci 2015; Fiordelisi and Ricci 2016; Fiordelisi and Galloppo 2018; Araujo, Minetti, and Murro 2021). Central banks implemented expansionary monetary policies by extending balance sheets and reducing reference interest rates below zero (e.g. Gambacorta, Hofmann, and Peersman 2014; Dell'Ariccia, Rabanal, and Sandri 2018; Kuttner 2018; Peydró, Polo, and Sette 2021). Thus, banks not only managed their liquidity and capital positions in a *de facto* double-constraint environment (Naceur, Marton, and Roulet 2018) but did so during a time of unconventional monetary policies.

Adding to the growing literature evaluating how banks act in response to the combination of capital and liquidity regulation,[3] we examine how banks respond to capital shocks when constrained by both capital and liquidity regulations in a period characterized by unconventional expansionary monetary policy. A capital shock is an ideal setting to examine bank behavior under stress because it allows us to examine whether banks treat capital and liquidity, proxied by the NSFR,[4] as substitutes or as complements. If capital and liquidity are treated as substitutes, a bank compensates for a capital shock by increasing its liquidity ratio in order to signal its ability

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to meet short-term obligations and to reduce creditors' uncertainty. Alternatively, when capital and liquidity are treated as complements, a bank focuses on its franchise value by taking on more liquidity risk to compensate for equity losses (DeYoung, Distinguin, and Tarazi 2018). Expansionary monetary policy may alter this relationship, making it easier for banks to satisfy the capital and liquidity requirements (Li 2020) and reducing the incentives to hold liquidity (Demiralp, Eisenschmidt, and Vlassopoulos 2021).

Since the NSFR is an aggregated regulatory ratio, banks may employ different policies to ensure compliance, including changes to credit volumes and risk. One frequently discussed bank-level policy in response to a capital shock is deleveraging/de-risking, which usually takes place through the reduction of bank lending (e.g. Hancock, Laing, and Wilcox 1995; Berrospide and Edge 2010; Kok et al. 2014; Noss and Toffano 2016; Meeks 2017; Mésonnier and Stevanovic 2017; Kanngiesser et al. 2020). Deleveraging/de-risking implies that a lower level of long-term funding and smaller liquidity reserves are needed to protect against unexpected outflows of funds; this means that if banks respond to capital shocks through deleveraging/de-risking, they will increase bank-level liquidity by taking on less liquidity risk. This is consistent with capital and liquidity being treated as substitutes. However, a bank might nevertheless search for bank-level policies that allow it to protect its franchise value, even in situations where it is already in the regulatory spotlight because of capital shortages. We refer to these policies as regulatory arbitrage, because the bank is shifting between assets that have similar risks for the bank but are subject to different regulatory requirements.

We test our hypotheses using a sample composed of European banks with data available in Standard and Poor's Capital IQ Pro (formerly Market Intelligence) database for the period 2010–2018. The final sample contains 532 banks, listed and non-listed, and 3,423 bank-year observations. We focus on these banks because, since they are relatively large, they are under stricter monitoring from both regulators and capital markets, and as such have been under pressure to comply with the NSFR from its 2010 announcement. Capital shocks are identified following the empirical strategy proposed by DeYoung, Distinguin, and Tarazi (2018), which focuses on decreases in capital ratios when a bank is already operating below the target capital ratio. This allows us to identify reasonably exogenous shocks on capital and to estimate their impact on bank liquidity, which is proxied by the NSFR.

Our results show that in a double-constraint environment, a capital shock does not impact aggregated bank liquidity. This is consistent with the view that imposing regulation on both capital and liquidity makes banks less willing to treat them either as substitutes or as complements. We extend the findings of DeYoung, Distinguin, and Tarazi (2018), which relate to large US banks and to a time when only capital regulation was in effect, to a European context and a period characterized by double constraints and an expansionary monetary policy regime. We observe no effect of looser monetary policy on the relationship between capital and liquidity, which indicates that unconventional monetary policies do not alter the relationship between capital and liquidity.

Although we find no evidence of a relationship between capital and liquidity at the aggregate level, more granular analysis reveals that banks act on certain bank-level policies to ensure compliance with regulations. In fact, especially during times when central banks rely on unconventional monetary policies, we find that banks respond to capital shocks by implementing de-risking policies, such as reducing total risk-weighted assets and shifting corporate lending to less risky securities primarily composed of government bonds. These results indicate that banks employ asset management rather than with funding management, which goes against the broader intent of the liquidity regulations.[5]

We provide several analyses that investigate further how banks respond to capital shocks by (i) splitting the sample period into two subperiods (2010–2014 and 2015–2018), (ii) dividing the sample between large and small banks, (iii) comparing the Euro area banks and non-Euro-area banks, and (iv) dividing banks according to their type. In general, our results remain similar but with subtle nuance such as: banks increase liquidity after a capital shock in the early period (2010-2014) but not in the late period (2015-2018); more active responses to the capital shocks among larger banks and among commercial banks; and an increase in security holdings for the Euro area banks but not for the non-Euro area banks.

Our results contribute to the literature in three main ways. This is the first attempt to analyze how banks act in response to a capital shock when acting in a double-constraint environment (capital and liquidity regulation) and unconventional monetary policy. Our work thus extends previous empirical studies that examine how banks operate under the new liquidity regulations (King 2013; Dietrich, Hess, and Wanzenried 2014; Imbierowicz and

Rauch 2014; Bonner and Eijffinger 2016; DeYoung and Jang 2016; Banerjee and Mio 2018). Our contribution is less concerned with banks' response to the regulations than with the implications of the regulations for banks under stress.

Second, we use banks' actions to clarify which bank-level policies they choose given the regulations in place. Drawing on the work of King (2013) and Banerjee and Mio (2018), we perform an analysis of various balance sheet restructurings employed by banks in response to capital shocks. This extends the findings of DeYoung, Distinguin, and Tarazi (2018), allowing us to uncover heterogeneity among banks following capital shocks, which is reflective of whether banks treat capital and liquidity as substitutes or as complements and the extent to which they utilize de-risking and regulatory arbitrage-like policies to achieve the latter.

Finally, our study addresses the implications of the unconventional monetary policies of the ECB in response to the sovereign debt crisis (e.g. Fiordelisi and Ricci 2016; Demiralp, Eisenschmidt, and Vlassopoulos 2021; Peydró, Polo, and Sette 2021; Legroux et al. 2022), which were contemporaneous with the introduction of the NSFR. Thus, our approach addresses capital shock responses considering the relationship between liquidity and capital, as well as accounting for the role of central bank interventions (Imbierowicz and Rauch 2014).

The rest of the paper is organized as follows. Section 2 reviews the literature and develops our hypotheses. Section 3 describes the data and methodology we use. Section 4 presents the main results. Section 5 is devoted to additional analyses and robustness checks. Section 6 concludes with the theoretical and managerial implications of the findings.

2. Related literature and hypotheses

The literature on banks' reactions to shocks can be divided into three streams (see, e.g. Kanngiesser et al. 2020): (i) studies concerned with isolating the shock itself and its impact on bank capital; (ii) studies analyzing regulatory shocks to bank capital and the implications for bank behavior; and (iii) studies that analyze how banks act in response to the shock. Our paper belongs to the third category, following on from Hancock, Laing, and Wilcox's (1995) seminal study of banks' responses to capital shocks. In this section, we review the literature to develop testable hypotheses regarding the impact of capital shocks on banks' liquidity position, the moderating effects of monetary policy actions, and what asset – and liability-side responses we expect from banks operating in a double-constraint environment.

2.1. Bank liquidity after a capital shock in a double-constraint environment

There is a broad consensus that liquidity requirements are necessary for effective regulation and that they complement capital regulations by reducing the inefficiencies of banks that do not internalize fire-sale externalities (e.g. Diamond and Rajan 2011; Tirole 2011; Kara and Ozsoy 2020). Since the introduction of the NSFR, banks have been constrained to maintain a balance between required stable funding (RSF) and available stable funding (ASF), which limits their incentives to increase the maturity of assets and/or reduce the maturity of liabilities.

When liquidity regulations constrain banks from reducing liquidity too much (i.e. in a double-constraint environment), it is not clear whether banks will treat capital and liquidity as complements or as substitutes when under stress (i.e. after a capital shock). When capital and liquidity are treated as complements, a bank focuses on its franchise value, meaning that it takes on more risk, including liquidity risk, to compensate for equity losses. The bank will be tempted to focus on regaining a stable capital position, for example by selling liquid assets and/or increasing reliance on wholesale funding (Ananou et al. 2021). On the other hand, if capital and liquidity are treated as substitutes, banks compensate for a capital shock with liquidity; that is, when a bank is hit by a capital shock, it increases its liquidity ratio to signal its ability to meet its short-term obligations and thus to reduce creditors' uncertainty.

Previous empirical research has been inconclusive on this point. Schmaltz et al. (2014) found that banks would increase stable deposits in response to a capital shock, indicating a substitution effect. In a pre-Basel III environment, DeYoung, Distinguin, and Tarazi (2018) found evidence of small US banks treating capital and liquidity as substitutes, increasing their liquidity ratios in response to a negative shock to their risk-weighted capital, even in the absence of liquidity regulations. However, Distinguin, Roulet, and Tarazi (2013) and Birn, Dietsch, and Durant (2017) found support for complementarity between capital and liquidity. Given the lack of clarity with regard to whether banks will respond to a capital shock by substitution or by complementarity, we formulate the following hypothesis:

H1. In a double-constraint environment, a capital shock positively (negatively) affects aggregated bank liquidity if capital and liquidity are treated as substitutes (complements).

2.2. *Monetary policy, bank liquidity, and capital shocks*

There is ample evidence that monetary policy interventions impact the value of banks (e.g. Ricci 2015; Fiordelisi and Ricci 2016; Fiordelisi and Galloppo 2018). Monetary conditions can also affect responses to a capital shock. On the one hand, expansionary monetary policy could decrease bank liquidity. Central bank excess liquidity and lower interest rates reduce the incentive for a bank to hold liquidity and encourage increases in bank lending (Demiralp, Eisenschmidt, and Vlassopoulos 2021). However, an expansionary monetary policy should, ceteris paribus, make it easier for banks to satisfy the capital and liquidity requirements (Li 2020), serving as a buffer for the banks (Aspachs, Nier, and Tiesset 2005) and further improving the resilience of firms' investment to economic conditions (Araujo, Minetti, and Murro 2021). Indeed, Legroux et al. (2022) have shown that ECB haircut policies helped French banks to reduce the liquidity mismatch (i.e. liquidity increased). Heider, Saidi, and Schepens (2019) also noted (1) that banks with higher franchise value take lower risks (de-risk) because they have more to lose, and (2) that negative interest rates should lead banks to decrease lending as well as take higher risk. The latter view is supported by Bubeck, Maddaloni, and Peydró (2020), who observed higher risk (running for yield) on balance sheets to compensate for the cost of negative interest rates, especially for banks with higher exposure to deposits.

Central bank policies may trigger different responses to a capital shock. Via excess liquidity from unconventional monetary policy, banks could undertake higher liquidity risk after a capital shock, either increasing the complementary of capital and liquidity or softening the substitution effect between the two. This leads us to the following hypothesis:

H2. In a double-constraint environment, unconventional monetary policy moderates the relationship between capital and liquidity following a capital shock.

2.3. *Bank-level policies*

Following DeYoung, Distinguin, and Tarazi (2018), our first hypothesis assesses the effects of capital shocks on aggregated bank liquidity. Our second hypothesis adds the effect of unconventional monetary policy. However, there is a wide variety of ways in which banks can ensure regulatory compliance and that are also indicative of what to expect from banks after a capital shock when acting in a double-constraint environment. Both King (2013) and Banerjee and Mio (2018) have identified different policies for banks to comply with liquidity regulations, including management of both assets and liabilities. King (2013) showed that increasing holdings of higher-rated securities and extending the maturity of wholesale funding are among the least costly options for banks seeking to satisfy liquidity regulations. Banerjee and Mio (2018) documented that banks in the United Kingdom reduced their dependency on short-term wholesale funding and non-resident deposits in response to liquidity regulations. Ananou et al. (2021) found that Dutch banks, in response to country-specific liquidity regulations introduced in 2003, increased their stock of corporate and retail loans relative to mortgage loans, and granted more short-term loans relative to their unaffected Euro area counterparts. While these studies illustrate how banks respond to liquidity regulations under normal conditions, our concern is with banks' responses under conditions of stress.

One frequently discussed bank-level policy in response to capital shock is deleveraging through a reduction of lending (Hancock, Laing, and Wilcox 1995; Berrospide and Edge 2010; Kok et al. 2014; Noss and Toffano 2016; Meeks 2017; Mésonnier and Stevanovic 2017; Kanngiesser et al. 2020). Hancock, Laing, and Wilcox (1995) found an overall credit reduction in response to capital shocks among US banks between 1984 and 1993; adjustments were made to all asset categories as well as to liabilities, and smaller banks contracted their balance sheets more than larger banks. Mésonnier and Stevanovic (2017) found that capital shocks to large US banks explained a substantial share in the variance of credit to firms and real activity. Kok et al. (2014) analyzed a sample of large public European banks and concluded that lending contracted only when banks reduced the size of their balance sheet while not raising capital. Using UK evidence, Noss and Toffano (2016) and Meeks (2017) found that a (regulatory-induced) capital shock led to a reduction in lending, with larger effects on corporate lending than on household lending because of differences in risk weights between corporates (higher) and households (lower).

These studies are concerned with banks' responses to capital shocks in an environment without liquidity regulations and, therefore, with policies aimed at strengthening bank capital regardless of their implications on banks' liquidity positions. If banks treat capital and liquidity as substitutes it makes sense to responds to capital shocks through deleveraging/de-risking. Reductions in total assets, or risk-weighted assets, also means that less long-term funding and smaller liquidity reserves are needed to protect against unexpected outflows. Therefore, we formulate the following hypothesis:

H3A. In a double-constraint environment, banks engage in deleveraging/de-risking after capital shocks.

However, some banks might prefer a complementary approach by seeking to implement bank-level policies that allow them to protect their franchise value without drawing the attention of regulators. We call these bank-level policies regulatory arbitrage, which means that a bank aims to maintain its risk level by shifting between assets that have risks that are similar for the bank but that are subject to different regulatory requirements. Since liquidity regulation is more complex to analyze than capital regulation (Bai, Krishnamurthy, and Weymuller 2018), a bank's incentives to engage in regulatory arbitrage will increase in a double-constraint environment (Dermine 2013). The design of the NSFR means that a straightforward policy toward regulatory arbitrage involves a bank shortening the maturity profile of its assets rather than lengthening the maturity profile of its funding instruments as intended by the regulations (Bonner and Eijffinger 2016; Ananou et al. 2021). We therefore propose our final hypothesis:

H3B. In a double-constraint environment, banks utilize regulatory arbitrage policies in response to capital shocks.

3. Methodology and data

3.1. Methodology

Our methodological approach determines the reaction of banks to capital shocks in a double-constraint environment with unconventional monetary policy, which is a suitable setting to examine bank-level policies under stress when both capital and liquidity regulation are present.

A key issue for our empirical strategy is to identify plausibly exogeneous negative changes in bank equity capital. As noted by DeYoung, Distinguin, and Tarazi (2018), this is a difficult task because we cannot rely either on natural experiments that assign negative capital shocks at random to some banks but not others, or on sudden and exogenous bank-specific negative shocks that would allow an event study. Accordingly, we employ a procedure that identifies shocks on the basis of a deviation of the bank's capital ratio from the internal target.

Following previous literature (e.g., Flannery and Rangan 2006; DeYoung, Distinguin, and Tarazi 2018; Bakkar, De Jonghe, and Tarazi 2019), we employ a partial adjustment model to estimate target capital ratios as a function of observable characteristics. This type of model has become standard in capital structure literature to account for deviations from target capital due to real-world frictions (e.g., Flannery and Rangan 2006; Bakkar, De Jonghe, and Tarazi 2019). For capital ratio, we rely on regulatory capital, which is defined as the ratio between the sum of Tier 1 and Tier 2 capital and the bank's risk-weighted assets.[6] The observable characteristics include bank size, standard deviation of the return on assets (ROA), and indicator variables for listed and too-big-to-fail banks. The model is as follows:

$$K^*_{i,t} = \beta X_{i,t-1} \tag{1}$$

where $K^*_{i,t}$ is the target capital ratios and $X_{i,t-1}$ is the vector of observable bank characteristics. While all banks strive to be at the target capital ratio, adverse external events can move a bank away from the target level. As a result, in a partial adjustment model, a bank's current capital ratio $K_{i,t}$ is a weighted average of its target capital ratio $K^*_{i,t}$ and the previous period's capital ratio, as well as a random shock ($v_{i,t}$):

$$K_{i,t} - K_{i,t-1} = \lambda(K^*_{i,t} - K_{i,t-1}) + v_{i,t} \tag{2}$$

We use λ to denote a constant proportion of the adjustment (scalar adjustment speed) that banks need to make between the operational and target levels of capital in each year. Then, by substituting (1) into (2) and rearranging, we obtain a model that we can empirically estimate:

$$K_{i,t} = \lambda\beta X_{i,t-1} + (1-\lambda)K_{i,t-1} + v_{i,t} \tag{3}$$

As described in DeYoung, Distinguin, and Tarazi (2018), this model allows us to recover the β coefficients necessary to compute the target capital ratios using Equation 1. We then estimate the internal equity capital ratio targets for each bank year. Once estimated, the internal capital ratio targets are used to identify the shocks to bank capital.[7]

Unfortunately, as noted by DeYoung, Distinguin, and Tarazi (2018), a deviation in a bank's capital from its internal target cannot be considered an exogenous event per se. For example, a bank that is below/above its desired internal capital target ratio can decrease/increase leverage until the capital ratio approaches the target level. Similarly, a change in required regulatory capital can force a bank to adjust its position. Although imposed on the bank exogenously, such changes are rarely sudden and unanticipated, making their use problematic. To minimize these concerns, following DeYoung, Distinguin, and Tarazi (2018), we only include shocks when a bank that is already operating at a capital ratio below its internal target experiences a further decrease in its capital ratio; we do this on the grounds that a bank that is already operating below the target level would prefer to increase than decrease its ratio.

These considerations imply that three conditions must be satisfied for a capital shock to take place: (1) there is a decrease in the equity capital ratio ($\Delta K_{i,t-1} < 0$); (2) the bank is already operating below its internal capital ratio target; and (3) the decrease leads to an even larger deviation from the bank's internal target.[8] Our main proxy for the shock, *ShockSize*, is the magnitude of the decline in the bank's equity capital in year *t−1* when all three conditions are satisfied.[9]

After identifying a shock, we proceed by testing the aggregate post-capital shock liquidity adjustment and the changes in the bank-level policies. Both models focus on the role of monetary policy to explore the shock behavior depending on the central bank's liquidity provision. We extend the model of DeYoung, Distinguin, and Tarazi (2018) by interacting the monetary policy in year *t* with the shock variable to capture the role of unconventional monetary policy as a moderating factor in the relationship between capital and liquidity. The model is Equation 4 (Eq. 4):

$$\begin{aligned}\Delta L_{i,t} = \beta * Below_{i,t-2} + \gamma * ShockSize_{i,t-1} + \theta * ShockSize_{i,t-1} * MP_{i,t} + \\ \vartheta * Controls_{i,t-1} + F_i + C_j * T_t + \varepsilon_{i,t}\end{aligned} \tag{4}$$

where $\Delta L_{i,t}$ is the change in the liquidity variable; $Below_{i,t-2}$ is a binary variable equal to 1 if bank *i* is below its capital ratio target at t−2; $ShockSize_{i,t-1}$ is a continuous variable capturing the size of the equity capital shock experienced by bank *i* in year t−1;[10] $MP_{i,t}$ is a monetary policy variable based on the size of the central bank's balance sheet, as in Peydró, Polo, and Sette (2021); $Controls_{i,t-1}$ is the vector of control variables which include a binary variable for listed banks and the log of the bank's total assets; and F_i are bank fixed effects. We include the country-by-year fixed effects (C_j*T_t) to control for time-varying unobserved country-level heterogeneity. Country-by-year fixed effects also allow us to control for the differences in the central banks' interventions in the provision of funding liquidity (see, e.g., Drechsler et al. 2016; Carpinelli and Crosignani 2021). Because we add country-by-year fixed effects, the model does not include $MP_{i,t}$ as a stand-alone variable. Finally, following DeYoung, Distinguin, and Tarazi (2018), we include the variable *Below* to control for changes in the liquidity variable for below-capital target banks that are non-shock related. We are primarily interested in the coefficients γ and θ. The coefficient γ indicates whether a capital shock is followed by an increase or a decrease in liquidity, that is, whether capital and liquidity are treated as substitutes or as complements. The coefficient θ indicates whether being in a period with a more expansive monetary policy amplifies or mitigates the baseline effect of the shock.

Next, we identify the bank-level policies (*BL_Policy*) through which the capital shocks are transmitted into changes in liquidity positions. The model is presented in Equation 5:

$$\begin{aligned} \Delta BL\_Policy_{i,t} &= \beta * Below_{i,t-2} + \gamma * ShockSize_{i,t-1} + \theta * ShockSize_{i,t-1} \\ &*MP_{i,t} + \vartheta * Controls_{i.t-1} + F_i + C_j * T_t + \varepsilon_{i,t} \end{aligned} \tag{5}$$

where the dependent variable $\Delta BL\_Policy_{i,t}$ is one of several variables used to identify how banks respond to the capital shock.[11] We estimate changes in the asset portfolio based on type, riskiness, and maturity or changes in liabilities by different types and maturities.

3.2. Sample description

We use the S&P Capital IQ Pro database to create our sample from all European Union banks except for the categories Federal Home Loan Bank (FHLB)/Development Banks and Central Banks. Using consolidated-level data, we consider both listed and non-listed banks with full coverage depth in the database. The sample period extends from 2010 to 2018. To avoid including banks that do not engage in traditional banking activities, and following DeYoung and Torna (2013), we require a non-missing value of total assets, non-negative deposits, and loans representing at least 25% of total assets.

Table 1 presents the final sample composition, which consists of 3,423 bank-year observations from 433 unique banking institutions with sufficient data to compute our shock variable. In Panel A, as expected, most banks are from the largest countries: Germany, France, Italy, and the United Kingdom. Panel B shows the number of observations by year, which increased from 327 in 2010–394 in 2018.[12]

3.3. Shocks

Table 2 presents summary statistics for the shock variables, as well as the distribution by year and country of the shocks. We identify a shock on a bank's equity in about 8% of the bank-year observations in our sample (262 shocks in total). Overall, compared to DeYoung, Distinguin, and Tarazi (2018), we find fewer shocks (10% vs. 28%) because our sampling period does not include the 2007–2008 financial crisis. The proxy for the equity capital shock, *ShockSize*, documents the magnitude of the decrease in banks' equity capital due to a shock. When a shock takes place, the average decline in equity capital is close to 1.00%. This magnitude is large enough to potentially affect a bank's liquidity position and bank-level policies.

The country distribution in Panel B shows that the highest numbers of shocks were in Germany (58), Italy (36), and France (28). This is to be expected, given that these countries have the largest numbers of banks in our sample. We also observe from Panel C that shocks were more common in the immediate aftermath of the great financial crisis (41 shocks in 2010), and then following the 2011–2012 sovereign debt crisis in Europe in 2013 and 2014 (51 and 38 shocks, respectively). However, we also observe a significant number of shocks in 2016 (47) and 2018 (56).

3.4. Liquidity, bank policies, and monetary policy variables

The NSFR is our bank liquidity proxy and has the advantage that it can be computed with non-proprietary data. Since S&P Market Intelligence does not provide the NSFR as reported by the bank for the full sample period and for all banks included in the analysis,[13] we create our own measure starting from the available end-of-year data. Following DeYoung, Distinguin, and Tarazi (2018), we also employ the adjusted NSFR (*NSFR_ADJ*), which is the NSFR adjusted for equity, to alleviate the concern that the inclusion of equity capital in the Basel III definition of the NSFR (as part of the ASF) can bias the results. The definitions of

Table 1. Sample Composition by Country, Year, and Bank Category.

Panel A. Country Breakdown

Country	N. Obs.	N. Banks	Country	N. Obs.	N. Banks
Austria	195	29	Italy	345	52
Belgium	93	13	Latvia	14	5
Bulgaria	60	8	Lithuania	24	8
Croatia	82	13	Luxembourg	47	9
Cyprus	39	6	Netherlands	98	15
Czech Republic	72	9	Poland	121	17
Denmark	293	40	Portugal	75	12
Estonia	24	4	Romania	72	9
Finland	67	9	Slovak Republic	41	7
France	343	57	Slovenia	27	3
Germany	567	81	Spain	142	32
Greece	62	13	Sweden	102	14
Hungary	70	9	United Kingdom	295	49
Ireland	53	9	**Total**	**3,423**	**532**

Panel B. Year Breakdown

Year	N. Obs.	Year	N. Obs.
2010	327	2015	394
2011	361	2016	391
2012	361	2017	398
2013	407	2018	394
2014	390	**Total**	**3,423**

This table presents the composition of the sample of European Union banks from S&P Market Intelligence for the period from 2010 to 2018, including the United Kingdom (Panel A). The number of observations per year is given in Panel B.

variables given in the Appendix report the construction of the variables. Our measure is highly and positively correlated with the NSFR reported by banks for the subset of available observations, with a correlation of approximately 0.60. The mean and median NSFR values in our sample are 108.07% and 108.30%, respectively, consistent with previous literature (e.g. DeYoung, Distinguin, and Tarazi 2018), which indicates that the average bank satisfies the minimum liquidity standards. When adjusted for equity, both mean and median NSFR are close to 96%.

Table 3 presents the liquidity proxies, monetary policy, and liability – and asset-side policy variables (as defined in the Appendix) that we use in our analysis. All variables are winsorized at 1% on both tails. The average bank in our sample had slightly less than €100 billion in total assets and risk-weighted assets of about €49 billion (49%). Our mean value for the average risk-weighted assets is lower than in previous literature. For example, Bakkar, De Jonghe, and Tarazi (2019) reported 73.4%, which was mainly driven by the differences in sample countries (European Union vs. OECD) and period (2010–2018 vs. 2001–2012).

We rely on several asset – and liability-side variables to identify the bank-level policies through which capital shocks are transmitted into changes in liquidity positions. The asset variables are the percentage change in total assets ($\%\Delta Assets$), risk-weighted-assets ($\Delta RWA/TA$), loans ($\Delta Loans/TA$), and total securities ($\Delta TotSec/TA$). Since the riskiness of a loan varies with its maturity and type, we examine different maturities and distinguish between corporate and retail loans as well as between domestic and non-domestic loans. On average, loans account for almost 64% of total assets in our sample, and around 47% of the loans had maturity longer than 12 months; that is, they were either medium-term (maturity from 1 year to 5 year) or long-term loans (maturity above 5 years). As expected, most loans issued by the sample banks were domestic (almost 50% of total assets), although non-domestic loans represented a significant portion of the banks' assets (12.2%).[14] Retail loans dominated by close to 36% of total assets, followed by corporate loans, accounting for approximately 29% of total assets, and total securities, which represent almost 19% of total assets (including government securities).

Our liability variables are changes in deposits over total assets ($\Delta Deposits/TA$), corporate ($\Delta CorpDep/TA$) and retail deposits ($\Delta RetailDep/TA$), and short-term wholesale funding over total assets ($\Delta StWhFund/TA$).

Table 2. Shock Size Variable.

Panel A. Summary Statistics

Variable	Mean	Median	Std. Dev.	Min.	Max.	N. Obs.
Shock Size	0.0100	0.0060	0.0139	0.0000	0.1077	262

Panel B. Shock Size by Country

Country	Mean	N. Obs.	Country	Mean	N. Obs.
Austria	0.0076	8	Latvia	0.0004	1
Belgium	0.0089	9	Lithuania	0.0064	4
Croatia	0.0851	3	Luxembourg	0.0110	2
Cyprus	0.0296	3	Netherlands	0.0311	4
Czech Republic	0.0072	5	Poland	0.0229	4
Denmark	0.0109	8	Portugal	0.0093	7
Finland	0.0033	4	Romania	0.0100	4
France	0.0064	28	Slovak Republic	0.0111	2
Germany	0.0077	58	Slovenia	0.0096	5
Greece	0.0167	5	Spain	0.0064	12
Hungary	0.0143	5	Sweden	0.0072	3
Ireland	0.0108	8	United Kingdom	0.0079	34
Italy	0.0089	36	**Total**	**0.0100**	**262**

Panel C. Shock Size by Year

Year	Mean	N. Obs.
2010	0.0070	41
2011	0.0131	8
2012	0.0144	8
2013	0.0117	51
2014	0.0081	38
2015	0.0359	5
2016	0.0112	47
2017	0.0061	8
2018	0.0080	56
Total	0.0100	262

This table presents the summary statistics for the shock variable. We define *Shock Size* as the magnitude of the decline in the bank's equity capital when the following three conditions are satisfied: (1) there is a decrease in the equity capital ratio (ΔK_(i,t-1) $<$ 0); (2) the bank is already operating below its internal capital ratio target; and (3) the decrease leads to an even larger deviation from the bank's internal target. Panel A reports summary statistics for the whole sample, Panel B presents shock size distribution across countries, and Panel C across time. All variables are winsorized at 1% on both tails.

Deposits stood at 55% of total assets and were largely composed of retail deposits (37% of total assets).

Our main analysis includes the size of the central bank's balance sheet divided by the nominal GDP of the reference country (Peydró, Polo, and Sette 2021) to account for monetary policy. This definition enables us to identify attempts by the ECB to provide liquidity following credit crunches after crises such as the sovereign debt crisis in 2011–2012.[15] These attempts can be regarded as an unconventional way to provide liquidity to the market, and we therefore capture them in a variable for unconventional monetary policy. Following Peydró, Polo, and Sette (2021), we standardize this variable by the nominal GDP of the reference country so that the size of the country does not affect our proxy.[16]

4. Empirical analysis

In this section, we present the main empirical analysis and discuss the results. First, we analyze the impact of a negative capital shock on the aggregate level of liquidity in a double-constraint environment, and then we examine in detail the bank-level policies that banks employ to satisfy regulatory requirements.

Table 3. Summary Statistics.

Variable	Mean	Median	Std. Dev.	Min.	Max.	N. Obs.
NSFR	1.0807	1.0830	0.2788	0.3286	2.1753	3282
NSFR_ADJ	0.9609	0.9651	0.2651	0.1764	1.8668	3282
Listed	0.0739	0.0000	0.2617	0.0000	1.0000	3423
Assets (ln)	16.8031	16.6639	1.8014	12.2715	21.1556	3423
%ΔAssets	0.0219	0.0165	0.1228	−0.3273	0.7176	3423
RWA/TA	0.4924	0.4851	0.1984	0.0736	0.9534	3307
Loans/TA	0.6380	0.6528	0.1429	0.2747	0.9203	3417
TotSec/TA	0.1858	0.1723	0.1135	0.0007	0.5387	3412
CorpLoans/TA	0.2907	0.2829	0.1550	0.0000	0.7025	1817
RetailLoans/TA	0.3547	0.3320	0.1970	0.0048	0.8649	1820
StLoans/TA	0.1459	0.1275	0.0958	0.0024	0.5515	2582
MtLoans/TA	0.1799	0.1814	0.0778	0.0016	0.4376	2537
LtLoans/TA	0.2864	0.2648	0.1739	0.0001	0.7991	2539
DomLoans/TA	0.4988	0.5130	0.2444	0.0000	0.9232	1126
NonDomLoans/TA	0.1222	0.0537	0.1666	0.0000	0.7973	1121
Deposits/TA	0.5458	0.5858	0.2266	0.0000	0.8997	3416
RetailDep/TA	0.3724	0.3843	0.1946	0.0000	0.8447	1065
CorpDep/TA	0.1934	0.1799	0.1134	0.0000	0.5688	1062
StWhFund/TA	0.1334	0.1072	0.1060	0.0002	0.5517	2526
Below	0.7000	1.0000	0.4583	0.0000	1.0000	3423
MP	0.6040	0.5500	0.8723	−2.0584	2.3348	3423

This table presents the summary statistics for the sample of banks in the European Union. All variables are winsorized at 1% on both tails. The sample period is from 2010 to 2018. Definitions of variables are reported in the Appendix.

Table 4. Determinants of the Net Stable Funding Ratio (NSFR) and the Adjusted Net Stable Funding Ratio (NSFR_ADJ).

	NSFR	NSFR_ADJ
Dependent Variable	(1)	(2)
Below	−0.0036	−0.0057
	[0.0057]	[0.0055]
ShockSize	−0.2693	−0.6176
	[0.4365]	[0.4447]
ShockSize * MP	0.6285	0.355
	[0.4823]	[0.4870]
Assets (ln)	−0.0372**	−0.0256*
	[0.0160]	[0.0141]
Listed	−0.0063	−0.0152
	[0.0332]	[0.0314]
Bank F.E.	Yes	Yes
Country-Year F. E.	Yes	Yes
Adjusted R^2	0.151	0.149
N. Obs.	3,239	3,239

This table presents estimates for the NSFR and the adjusted NSFR. We report the parameters of Eq. 1 estimated on a sample of European Union banks for the period 2010–2018. Definitions of variables are reported in the Appendix. All models are estimated with bank – and country-year fixed effects, and standard errors are clustered at bank level. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

4.1. Impact of shock on liquidity

Table 4 presents estimates of our baseline models to examine how banks adjust liquidity following a capital shock in a double-constraint environment, using two dependent variables: the NSFR and the adjusted NSFR.

Table 4 shows that a negative capital shock in a double-constraint environment does not impact the aggregate level of liquidity in the affected banks. This result is consistent with the findings of DeYoung, Distinguin, and

Table 5. Asset-side Policies.

	%ΔAssets	ΔRWA/TA	ΔLoans/TA	ΔTotSec/TA
Dependent Variable	(1)	(2)	(3)	(4)
Below	0.0050	−0.0083**	−0.0046*	0.0029
	[0.0065]	[0.0033]	[0.0026]	[0.0024]
ShockSize	−0.9624	0.0998	0.1945	−0.1786
	[0.5913]	[0.2451]	[0.1875]	[0.1996]
ShockSize * MP	1.1299	−0.8128***	−0.7474***	0.5658***
	[0.6932]	[0.2741]	[0.1937]	[0.1872]
Assets (ln)	−0.1449***	0.0154**	0.0096	−0.0091*
	[0.0297]	[0.0063]	[0.0061]	[0.0053]
Listed	−0.0286	0.0055	−0.0027	0.0032
	[0.0326]	[0.0088]	[0.0099]	[0.0100]
Bank F. E.	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes
Adjusted R^2	0.175	0.131	0.117	0.160
N. Obs.	3423	3281	3415	3408

This table presents the estimates for asset-side policies. We report the parameters from Eq. 2 estimated on a sample of European Union banks for the period 2010–2018. Definitions of variables are reported in Appendix A. All models are estimated with bank – and country-year fixed effects, and standard errors are clustered at bank level. Mean Y indicates the country mean of the dependent variable. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

Tarazi (2018) for the capital regulation environment. In fact, after controlling for being below the target capital ratio (*Below*), the size of the bank (*Assets (ln)*), and its listing status (*Listed*), the variable *ShockSize* has a negative but not statistically significant coefficient. These results remain stable in the presence of unconventional monetary policy. We document similar results using the adjusted NSFR (*NSFR_ADJ*) as a dependent variable, and our monetary policy ($ShockSize * MP$) estimations do not yield significant results. Overall, these results suggest that banks operating below their internal capital targets are unwilling to alter their liquidity position in response to a capital shock. However, liquidity measures such as the NSFR are composite measures (NSFR = RSF/ASF), which means that even if the NSFR remains stable there can be substantial changes in the RSF and ASF as long as these changes are in the same direction. For example, as indicated by Araujo, Minetti, and Murro (2021), some banks might prefer to reduce the RSF by shifting into shorter maturity assets rather than increasing the ASF by increasing longer term liabilities as intended by the regulations. In what follows we analyze these bank-level policies to identify whether banks treat capital and liquidity as substitutes or complements in response to capital shocks.

4.2. Bank-level policies

We use bank-level analysis to examine whether banks employ specific bank-level policies in response to a capital shock, thereby uncovering adjustments that cannot be observed by studying the aggregate liquidity level. First, we examine the asset-side policies, and then we focus on the liability-side policies. We also determine whether these responses are amplified in periods of unconventional monetary policy.

4.2.1. Asset-side policies

Table 5 reports the results of our analysis of the asset-side policies, estimating the model in Eq. 2 for several dependent variables. Although we do not observe significant adjustments in asset size (%Δ*Assets*, Column 1), we observe that the coefficient for the interaction term $ShockSize * MP$ is negative and statistically significant at the 1% level when the dependent variable is change in risk-weighted assets *(*Δ*RWA/TA*, Column 2). Following a negative capital shock, in periods of unconventional monetary policy, banks tended to decrease the riskiness of their assets. Thus, banks used the same liquidity buffer to counter fewer risks.

Column 3 examines the change in loans (as a percentage of total assets, Δ*Loans/TA*). We find that banks tended to decrease overall lending activity when their capital decreased following a negative capital shock and unconventional monetary policy, a result consistent with the findings of Naceur, Marton, and Roulet (2018).

Table 6. Loan Breakdown by Type and Maturity.

	ΔCorpLoans/TA (1)	ΔRetailLoans/TA (2)	ΔStLoans/TA (3)	ΔMtLoans/TA (4)	ΔLtLoans/TA (5)	ΔDomLoans/TA (6)	ΔNonDomLoans/TA (7)
Below	−0.0031	−0.0007	0.0002	−0.0077**	−0.0137***	−0.0063	−0.0004
	[0.0036]	[0.0025]	[0.0034]	[0.0031]	[0.0048]	[0.0050]	[0.0030]
ShockSize	−0.1274	0.1757	0.1909	−0.2156	−0.22	0.2632	0.1366
	[0.3074]	[0.1461]	[0.2335]	[0.1810]	[0.2463]	[0.2403]	[0.2243]
ShockSize ∗ MP	−1.1400***	−0.2483	−0.1155	0.2263	−0.0811	−0.4464	−0.1069
	[0.3141]	[0.1872]	[0.2219]	[0.1877]	[0.2562]	[0.3470]	[0.2135]
Assets (ln)	0.0046	0.0136	0.0089**	0.0002	−0.0084	0.0116	−0.0036
	[0.0096]	[0.0088]	[0.0045]	[0.0053]	[0.0066]	[0.0100]	[0.0066]
Listed	0.0128	−0.0223*	0.0023	−0.0014	−0.0171	−0.1073***	0.008
	[0.0162]	[0.0128]	[0.0126]	[0.0060]	[0.0118]	[0.0167]	[0.0120]
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.125	0.061	0.056	0.068	0.047	0.168	0.060
N. Obs.	1757	1760	2447	2401	2401	1083	1075

This table presents the estimates for loan type and maturity. We report the parameters from Eq. 2 estimated on a sample of European Union banks for the period 2010–2018. Definitions of variables are reported in Appendix A. All models are estimated with bank – and country-year fixed effects, and standard errors are clustered at bank level. Mean Y indicates the country mean of the dependent variable. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

On the other hand, DeYoung, Distinguin, and Tarazi (2018) found no effect of capital shock on the change in loans in a single-constraint environment. In addition, we analyze the variation in total securities ($\Delta TotSec/TA$), which includes primarily government bonds held by banks (Column 4). We observe that the coefficient for the interaction term $ShockSize * MP$ variable is positive and statistically significant at the 1% level. Like Naceur, Marton, and Roulet (2018), we find that banks preferred securities when faced with capital shocks. Overall, these results indicate that banks tended to reallocate funds between asset types to respond to a shock while complying with liquidity requirements. The consequence of moving from lending into securities is that a capital shock drains liquidity from riskier areas of the economy (such as corporate loans) when banks use policies for regulatory compliance. This shift could create tensions in the balance sheet for a bank's borrowers, who face a reduction in their credit supply.

The decrease in lending observed in Column 3 prompted us to examine in detail the change in lending activity to determine which type of loan was most affected by the capital shock. Table 6 presents the breakdown of loans by type and maturity. Banks adjusted to the shocks by decreasing corporate loans, as indicated by the negative and statistically significant coefficient of the $ShockSize * MP$ variable. This decrease can be explained by deleveraging (Blundell-Wignall and Atkinson 2012) and by the credit crunch that prevailed in Europe following the financial crisis (Acharya et al. 2019). Moreover, corporate loans are assigned higher risk weights in the calculation of the minimum regulatory capital. Thus, when faced with a capital shock, banks tended to replace risky corporate loans with government securities (Naceur, Marton, and Roulet 2018). Retail loans were the least affected by negative capital shocks. Columns 3–5 in Table 6 show our results for loans of different maturities. The coefficient on $ShockSize * MP$ is never statistically significant. We observe a decrease in domestic lending, whereas non-domestic loans did not change. A possible explanation is that banks were trying to adjust to the capital shock by decreasing lending in markets affected by the crisis in Europe in the early phase of our sample period.

Overall, these results indicate that banks, to avoid the impact of a negative capital shock on their liquidity position, adjusted their asset side by shifting their activities from risky and illiquid credit activities to financial securities.

4.2.2. Liability-side policies

We complement our analysis by examining bank-level liability-side policies and the adjustments that banks pursue in a double-constraint environment following a negative capital shock. Table 7 reports estimates for key liability-side policies through which capital shocks can be transmitted into liquidity positions. The model in Column 1 shows that deposits as a proportion of total assets ($\Delta Dep/TA$) did not change following a negative capital

Table 7. Liability-side Policies.

	ΔDep/TA (1)	ΔRetailDep/TA (2)	ΔCorpDep/TA (3)	ΔStWhFund/TA (4)
Below	−0.0024	−0.0063	0.0147	0.0037
	[0.0025]	[0.0052]	[0.0108]	[0.0034]
ShockSize	−0.0149	−0.3274	1.0496*	−0.1399
	[0.1918]	[0.2463]	[0.5876]	[0.2190]
ShockSize ∗ MP	−0.2077	0.757	0.6262	0.1282
	[0.2456]	[0.4916]	[1.0683]	[0.2424]
Assets (ln)	0.0185***	0.0221	−0.0036	−0.0164**
	[0.0046]	[0.0142]	[0.0410]	[0.0082]
Listed	0.0109	0.0055	−0.0618	0.0063
	[0.0165]	[0.0109]	[0.0408]	[0.0137]
Bank F. E.	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes
Adjusted R^2	0.148	0.180	0.234	0.128
N. Obs.	3414	1012	1010	2237

This table presents the estimates for liability-side policies. We report the parameters from Eq. 2 estimated on a sample of European Union banks for the period 2010–2018. Definitions of variables are reported in Appendix A. All models are estimated with bank – and country-year fixed effects, and standard errors are clustered at bank level. Mean Y indicates the country mean of the dependent variable. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

shock, even in a period of unconventional monetary policy. Corporate deposits ($\Delta CorpDep/TA$) increased after a shock, but this effect was not enough to generate an increase in total deposits.

This finding implies that banks did not experience a run on deposits when facing a capital shock, probably because of well-functioning deposit insurance schemes across the European Union.[17] Short-term wholesale funding ($\Delta StWhFund/TA$) also remained relatively stable and did not change because of a negative capital shock in a period of unconventional monetary policy. In part, this result can be explained by the fact that following the 2008 financial crisis, wholesale funding has been increasingly difficult to access; funding costs have risen, and there is rollover risk (Acharya, Gale, and Yorulmazer 2011) due to debtholders' concerns over banks' financial soundness. Overall, it seems that the affected banks did not substantially alter their liability side.

Our evidence suggests that banks responded to a shock by adjusting both assets and liabilities. The findings indicate that they made more adjustments to the asset side than to the liability side; that is, to remain compliant with both the capital and liquidity requirements after a negative capital shock, they increased their exposure to securities while cutting back on corporate lending. From a capital perspective this indicates de-risking, but from a liquidity perspective it allows banks to strengthen their NSFR without investing in more expensive long-term funding. The latter consideration implies that there was a regulatory arbitrage strategy embedded in the banks' response to capital shock, which goes against regulatory intention.

5. Additional analyses and robustness checks

Following our analyses of the asset – and liability-side policies, which document significant adjustments in response to capital shocks, we expand our analysis to examine different central bank policies as well as sample and bank characteristics: early and late sample periods, negative interest rates, bank size, euro area vs. non-euro area banks, and bank type.

5.1. Early vs. late period

Our sample encompasses several central banks (henceforth CBs) and numerous actions and events. Accordingly, our first robustness check determines whether our empirical results for the full sample period are confirmed in smaller, more homogenous subperiods. We split the sample period into two subperiods: early (2010–2014) and late (2015–2018). As noted in Section 1, three are three key reasons for this split: first, the NSFR was introduced in 2010 but was more strictly monitored by key regulatory authorities from 2015; second, ECB monitory policy programs follow two rather distinct phases, namely 2010–2014 and 2015–2016;[18] and third, the 2015–2018 period was a negative interest rate environment, but the early period was not. Because of differences in CB policies, it is possible that there were different incentives for bank behavior and that these affected balance sheets.[19]

As it can be shown in Table 2, the early period, which is marked by the sovereign debt crisis, has more shocks than the late period (146 vs 116). Both NSFR and NSFR adjusted are higher in the late period than in the early period (1.12 vs 1.04; and 0.99 vs 0.93, respectively), consistent with an improvement in the economic conditions as well as a higher attention on this measure in the second part of our sample period.

The estimates of our baseline models are presented in Table 8. Panel A examines how banks adjusted their liquidity policies following a capital shock in the double-constraint environment of the 2010–2014 and 2015–2018 periods. As in the main results, we use both *NSFR* and *Adjusted NSFR* as dependent variables. We find that, after controlling for other bank characteristics, a capital shock did not impact the aggregate level of liquidity in either period. However, when we interact the shock with the unconventional monetary policy variable, we observe differences in bank behavior between the sample periods. During the 2010–2014 period, banks operating below their internal capital targets increased the aggregate level of liquidity when CBs used more unconventional monetary policies, as indicated by the positive and statistically significant interaction term. This is consistent with banks using the injected liquidity to reinforce their own liquidity position and to signal that, despite the negative capital shock, they remained prudent. Thus, in the early period, there is some evidence that banks were increasing liquidity in a period of strong instability and uncertainty. We do not find similar results for the 2015–2018 period, which suggests that the banks did not alter their liquidity position in response to capital shocks.

Panels B and C examine asset – and liability-side adjustments in the 2010–2014 and 2015–2018 periods, respectively. From Panel B, we find that banks reduced overall lending, primarily driven by reductions in corporate lending. These results are in line with the literature that finds a decrease in corporate loan supply during the crisis period (e.g. Becker and Ivashina 2018). On the other hand, we document a strong increase in total securities, mostly driven by the increase in government debt. Panel C reports qualitatively similar results, although the effect on corporate loans and total securities appears to be smaller.

5.2. Negative interest rates

To measure the unconventional monetary policy, we focus on the size of the central banks' balance sheet (Peydró, Polo, and Sette 2021). However, during our sample period, central banks had another important policy tool to mitigate the effect of the 2007–2008 financial crisis and the European sovereign debt crisis: using negative interest rates to provide liquidity to the overall economy. Since negative interest rates impact banks' profitability, they may affect how banks manage their liquidity. To examine this issue, we create a dummy to capture negative interest rate periods (*Negative Int.Rate*), which should mitigate the potentially confounding role of this variable to the capital shocks.

The estimates of our baseline models are presented in Table 9. Panel A reports results for the models that examine bank liquidity position adjustments. Adding the interaction of the shock variable with the negative interest rates leaves our results unchanged. In both model specifications, with *NSFR* and *NSFR_ADJ* as dependent variables, respectively, we notice that this interaction is positive but not statistically significant. These results indicate that negative interest rates did not act as a confounder to the capital shocks in our analysis.

Panel B reports asset – and liability-side adjustments. Again, the analysis confirms our baseline results, and the interaction of capital shock with the negative interest rate variable remains insignificant across model specifications. The only exception is in the corporate loan regression, where the interaction is positive, counterbalancing the negative coefficient on the interaction between the capital shock and the monetary policy variable.

5.3. Bank size

Previous studies have documented that bank size affects regulatory responses (Berger and Bouwman 2009; Aiyar, Calomiris, and Wieladek 2016) and shock responses (DeYoung, Distinguin, and Tarazi 2018). For instance, the impact of tightened capital requirements that cause a reduction in credit supply is stronger for smaller banks

Table 8. Early vs. Late Period.

Panel A. NSFR

	Early period		Late Period	
	NSFR	NSFR_ADJ	NSFR	NSFR_ADJ
Dependent Variable	(1)	(2)	(3)	(4)
ShockSize	−0.666	−1.0767	0.5089	0.2407
	[0.6280]	[0.6682]	[1.2410]	[1.1474]
ShockSize ∗ Crisis MP	2.3463***	1.6680**	0.1191	−0.1003
	[0.6455]	[0.6855]	[0.6192]	[0.6154]
Controls	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes
Adjusted R^2	0.160	0.140	0.168	0.195
N. Obs.	1751	1751	1488	1488

Panel B. Asset – and Liability-side Policies: Early Period

Dependent Variable	%ΔAssets	ΔRWA/TA	ΔLoans/TA	ΔCorpLoans/TA	ΔRetailLoans/TA	ΔStLoans/TA	ΔTotSec/TA	ΔDep/TA	ΔStWhFund/TA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ShockSize	−0.1564	−0.3016	0.0822	0.0658	0.0348	0.0446	−0.2483	−0.4214	−0.204
	[0.6722]	[0.3373]	[0.3058]	[0.3144]	[0.2694]	[0.2240]	[0.2537]	[0.3103]	[0.5005]
ShockSize ∗ Crisis MP	2.0588	−1.7304***	−0.8492**	−1.2596***	−0.0911	0.1632	0.9538***	0.1319	1.7583
	[1.5779]	[0.4882]	[0.3571]	[0.4012]	[0.3190]	[0.4932]	[0.3232]	[0.4524]	[1.1529]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F.E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.249	0.161	0.136	0.174	0.072	0.079	0.155	0.164	0.157
N. Obs.	1846	1767	1845	969	972	1365	1843	1843	1068

Panel C. Asset – and Liability-side Policies: Late Period

Dependent Variable	%ΔAssets	ΔRWA/TA	ΔLoans/TA	ΔCorpLoans/TA	ΔRetailLoans/TA	ΔStLoans/TA	ΔTotSec/TA	ΔDep/TA	ΔStWhFund/TA
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
ShockSize	−1.6924**	−0.3534	0.4249	1.3106***	−0.2404	0.4522	−0.3903	0.8285*	−0.5389
	[0.8573]	[0.5516]	[0.4151]	[0.3509]	[0.6774]	[0.5969]	[0.3526]	[0.4474]	[0.4366]
ShockSize ∗ Crisis MP	0.8018*	−0.5350*	−0.8083***	−0.4440*	−0.23	−0.3535	0.3572**	−0.1673	−0.121
	[0.4253]	[0.3184]	[0.1858]	[0.2668]	[0.2804]	[0.3172]	[0.1793]	[0.3219]	[0.2593]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.352	0.171	0.171	0.100	0.129	0.071	0.137	0.138	0.147
N. Obs.	1577	1514	1570	788	788	1082	1565	1571	1169

This table presents estimates for the NSFR and the adjusted NSFR (Panel A) and asset-side and liability-side (Panel B) policies for subsamples split into an early period (2010–2014) and a late period (2015–2018). Definitions of variables are reported in Appendix A. All models include the same explanatory variables as in Tables 3–7 and are estimated with bank and country-year fixed effects. Standard errors are clustered at bank level. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

Table 9. Negative Interest Rate Dummy.

Panel A. NSFR

Dependent Variable	NSFR (1)	NSFR_ADJ (2)
ShockSize	−0.3289	−0.7342*
	[0.4373]	[0.4447]
ShockSize ∗ Crisis MP	0.5209	0.1449
	[0.5265]	[0.5275]
ShockSize ∗ Negative Int.Rate	0.6961	1.3594
	[0.9251]	[0.9241]
Controls	Yes	Yes
Bank F. E.	Yes	Yes
Country-Year F. E.	Yes	Yes
Adjusted R^2	0.151	0.149
N. Obs.	3239	3239

Panel B. Asset – and Liability-side Policies

Dependent Variable	%ΔAssets (1)	ΔRWA/TA (2)	ΔLoans/TA (3)	ΔCorpLoans/TA (4)	ΔRetailLoans/TA (5)	ΔStLoans/TA (6)	ΔTotSec/TA (7)	ΔDep/TA (8)	ΔStWhFund/TA (9)
ShockSize	−0.8636	0.0708	0.1846	−0.1547	0.1864	0.2019	−0.1437	−0.0811	−0.1142
	[0.6173]	[0.2610]	[0.1899]	[0.3000]	[0.1462]	[0.2329]	[0.1999]	[0.1932]	[0.2196]
ShockSize ∗ Crisis MP	1.3161*	−0.8641***	−0.7660***	−1.1887***	−0.2292	−0.079	0.6316***	−0.3322	0.2021
	[0.7705]	[0.2925]	[0.2064]	[0.3161]	[0.1885]	[0.2531]	[0.2088]	[0.2457]	[0.2488]
ShockSize ∗ Neg.Int.	−1.1301	0.3337	0.1126	1.9410**	−0.7583	−0.1556	−0.3993	0.756	−0.3453
	[1.1044]	[0.5115]	[0.4268]	[0.8887]	[0.5873]	[0.3156]	[0.4458]	[0.4780]	[0.4808]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.175	0.130	0.117	0.127	0.061	0.055	0.160	0.149	0.128
N. Obs.	3423	3281	3415	1757	1760	2447	3408	3414	2237

This table presents estimates for the NSFR and the adjusted NSFR (Panel A) and asset-side and liability-side policies. Definitions of variable definitions are reported in the Appendix. All models include the same explanatory variables as in Tables 3–7 and are estimated with bank, country and year fixed effects. Standard errors are clustered at bank level. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

than for larger ones (Aiyar, Calomiris, and Wieladek 2016). Thus, the ability of banks to manage their assets and liabilities can vary with their size. An intuition behind these results is that larger banks have better access to financial markets (Choi and Choi 2021). In addition, larger banks tend to be subject to stricter monitoring and therefore under greater pressure to comply with regulations. Banks of different sizes also differ in their business models: smaller banks tend to be more focused on traditional financial intermediation activities (lending and deposits), whereas larger banks are more involved in trading and wholesale funding activities.

Although our sample is composed of relatively large banks, there is nevertheless substantial variation in the size of the banks included. Accordingly, we split the sample into smaller and larger banks, with total assets above and below €10 bn, respectively. Replicating the analysis in Tables 4–7 for the subsamples of larger and smaller banks, we find that the *ShockSize* variable behaved differently using the asset measure. We report these results in Table 10. While the larger banks did not adjust their overall liquidity positions, the smaller banks tended to decrease theirs, as reflected in the negative and statistically significant coefficient for *NSFR_ADJ*. The larger banks tended to increase overall liquidity only when facing adverse capital shocks in periods of unconventional monetary policy, but this result is not robust to the use of the adjusted NSFR (*NSFR_ADJ*). Examining further the different asset – and liability-side policies, we observe that the larger banks tended to increase their use of securities while decreasing the riskiness of their assets at times of unconventional monetary policy. This suggests that the larger banks used securities as a mechanism to balance their liquidity shortages. Moreover, the smaller banks tended to increase retail loans following capital shocks. In terms of liability-side adjustments, however, we do not observe significant differences between the two subsamples. Overall, these results document a heterogeneous response to capital shocks depending on the size of the bank, even among the relatively large banks in our sample. Thus, our results suggest that larger institutions have more resources to act strategically in a double-constraint environment.

To corroborate our findings, we perform the same analysis on a smaller subset of banks: those defined by the ECB as significant credit institutions (henceforth SCIs).[20,21] Because of their importance, SCIs are under the direct supervision of the ECB. Thus, these institutions are monitored more stringently by both regulators and capital markets, and we would expect them to act more decisively in response to an adverse capital shock in a double-constraint environment. From S&P Market Intelligence we obtained information concerning which banks are considered SCIs and from which years, which account for 508 bank-year observations in our sample and 42 shocks. Not surprisingly, SCIs are larger and more likely to be listed than the average sample bank. In fact, almost 18% of the observations for the SCI sample belong to listed banks. In terms of liquidity, SCIs are similar to the remaining banks. In fact, the average NSFR (adjusted NSFR) for the SCI sample is 1.06 (0.96), similar to the values shown in Table 3 for the full sample. In unreported analysis, we find that SCIs do not substitute capital with liquidity as a response to adverse capital shock. DeYoung, Distinguin, and Tarazi (2018) documented a similar result for for larger banks. Further analysis of asset-side adjustments reveals very active responses, consistent with the view that regulators and market monitoring push these banks to adjust immediately to a shock. Like the average sample bank, SCIs tended to decrease the riskiness of their assets and their lending activity while increasing investments in the securities portfolio, in particular in times characterized by unconventional monetary policies. The decrease in loans was mainly driven by a reduction in corporate and short-term loans. Given their flexibility and resources, it comes as no surprise that these SCIs did not experience a decrease in their deposit levels.

5.4. Euro area banks

Our sample includes banks in the euro area (that is, banks governed by a unique CB with a common monetary policy) and non-Euro area banks that are under control of their national CBs; thus, there could be relevant differences within our sample in terms of monetary policy. Therefore, as a robustness check, we perform additional analyses to compare the liquidity and asset – and liability-side adjustments for each subsample. Non-euro banks, which represent about one-third of the sample, i.e. 1190 observations out of 3,423 observations, accounting for 70 shocks. They show a higher NSFR than Euro-banks: 1.19 vs 1.02 (adjusted NSFR: 1.05 vs. 0.91). Overall, this is consistent with banks in the Euro area suffering more the effects of the crisis in the early part of the sample.

Table 10. Large and Small Banks.

Panel A. NSFR

	Large Banks		Small Banks	
Dependent Variable	NSFR (1)	NSFR_ADJ (2)	NSFR (3)	NSFR_ADJ (4)
ShockSize	−0.3796	−0.566	−0.4321	−1.0622*
	[0.6598]	[0.6715]	[0.6857]	[0.6297]
ShockSize ∗ Crisis MP	1.0224*	0.6556	1.214	1.0226
	[0.5981]	[0.6012]	[0.8883]	[0.8969]
Controls	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes
Adjusted R^2	0.132	0.122	0.216	0.222
N. Obs.	2156	2156	1083	1083

Panel B. Asset – and Liability-side Policies: Large Banks

Dependent Variable	%ΔAssets (1)	ΔRWA/TA (2)	ΔLoans/TA (3)	ΔCorpLoans/TA (4)	ΔRetailLoans/TA (5)	ΔStLoans/TA (6)	ΔTotSec/TA (7)	ΔDep/TA (8)	ΔStWhFund/TA (9)
ShockSize	−0.6451	0.2396	0.3288	0.2606	0.0939	−0.0287	−0.3667*	0.0191	0.045
	[0.5956]	[0.3014]	[0.2438]	[0.2657]	[0.2620]	[0.2044]	[0.2129]	[0.2691]	[0.3176]
ShockSize ∗ Crisis MP	0.7201	−0.8379***	−0.7919***	−1.0315***	−0.0816	−0.1951	0.6522***	−0.0442	0.0215
	[0.7551]	[0.2968]	[0.2200]	[0.2967]	[0.2944]	[0.1538]	[0.1983]	[0.3236]	[0.2660]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.209	0.125	0.127	0.163	0.069	0.010	0.177	0.171	0.135
N. Obs.	2288	2180	2281	1199	1202	1648	2278	2284	1530

Panel C. Asset and Liability-side Policies: Small Banks

Dependent Variable	%ΔAssets (1)	ΔRWA/TA (2)	ΔLoans/TA (3)	ΔCorpLoans/TA (4)	ΔRetailLoans/TA (5)	ΔStLoans/TA (6)	ΔTotSec/TA (7)	ΔDep/TA (8)	ΔStWhFund/TA (9)
ShockSize	−1.8851**	−0.1667	0.2615	−0.7659*	0.5713**	0.2641	0.1052	0.0812	−0.6679
	[0.9236]	[0.4758]	[0.3759]	[0.4424]	[0.2477]	[0.7485]	[0.3864]	[0.2833]	[0.5406]
ShockSize ∗ Crisis MP	2.0310*	−0.4105	−0.7	−0.6436	−0.673	0.1548	0.309	−0.5111	0.4637
	[1.0352]	[0.7057]	[0.5248]	[0.8274]	[0.4420]	[1.0842]	[0.4960]	[0.4394]	[0.7109]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.292	0.207	0.202	0.141	0.129	0.182	0.178	0.211	0.216
N. Obs.	1135	1101	1134	558	558	799	1130	1130	707

This table presents estimates for the NSFR and adjusted NSFR (Panel A), and asset-side (Panel B) and liability-side (Panel C) policies for large and small banks. Models are estimated on a sample of European Union banks for the period 2010–2018. All models include the same explanatory variables as in Tables 3–7 and are estimated with bank – and country-year fixed effects. Standard errors are clustered at bank level. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

Euro area banks are larger, but they list themselves in a stock exchange less frequently than non-Euro area banks (5.72% vs 10.42%).

Table 11 reports the results, which are similar to those for the full sample; that is, overall liquidity remained unchanged for both subsamples following a capital shock and crisis period (Panel A). However, the results for asset-side adjustments show that both Euro area and non-Euro area banks were active in adjusting the asset side of their balance sheets. Notably, Euro area banks tended to decrease the riskiness of their assets by decreasing overall loans (in particular, corporate loans) following capital shocks in a period of unconventional monetary policy. We find similar results for the non-Euro area banks. Consistent with previous literature (e.g. Acharya and Steffen 2015; Abbassi et al. 2016; and Becker and Ivashina 2018), we find that theEuro area banks increased total securities, but we find no such results for non-Euro area banks. A possible explanation for the increase in security holdings could be the high yields offered by government bonds in the Euro area's peripheral countries (Acharya and Steffen 2015).

We expand our analysis to study a particular group of countries, the so-called GIIPS (Greece, Ireland, Italy, Portugal, and Spain). These countries drifted into severe crisis as concerns about their indebtedness made it increasingly difficult to refinance their outstanding debt, leading to a deterioration of their creditworthiness that spilled over into the financial sector (see, e.g. Acharya and Steffen 2015). Since these countries suffered more than others during the crisis, we study the responses of their banks. In untabulated results, as in the main sample, we find that banks did not alter their liquidity following a capital shock.[22] However, examination of the asset and liability sides shows that GIIPS banks decreased lending, especially corporate lending. Thus, we find that, following a capital shock, banks in these countries tended to increase short-term loans and to invest in securities in times of unconventional monetary policy. This result may be due to an increased home bias of GIIPS banks in buying bonds issued by local governments (Acharya and Steffen 2015).

5.5. Bank type

We control for bank type by dividing the sample into commercial banks and savings/thrift mutual banks.[23] Commercial banks are financial institutions whose main purpose is to serve individuals, small – and large-scale organizations, and businesses. Savings and thrift mutual banks serve and finance local communities, usually in the areas of agriculture, small industry, and trade (Castelló, Trias, and Arribas 2018).[24] Savings/thrift mutual banks are not necessarily small banks. In fact, in our sample the average size of the two subsamples is similar. However, commercial banks show a higher value for NSFR (Adjusted NSFR) than savings banks, 1.10 (0.98) vs 1.01 (0.90).

Given these differences, we would expect different reactions from these types of banks to an equity shock.[25] As in the results for the full sample, in this double-constraint environment, an adverse capital shock did not affect the aggregate level of liquidity for commercial banks or for savings and thrift mutual banks. However, the responses of the two bank types differed in terms of their asset – and liability-side policies. Commercial banks were more active in adjusting their asset composition following a negative capital shock, especially at times of unconventional monetary policy. They tended to decrease the riskiness of their assets and to reduce their overall lending activity, which was mainly driven by corporate lending. The observed decrease in lending was compensated by an increased investment in their securities portfolios. Savings and thrift mutual banks managed their assets less actively than their commercial counterparts. Apart from a marginal decrease in the riskiness of their assets in period characterized by a strong intervention by central banks, they made hardly any adjustments to their portfolios.

Finally, to examine differences depending on the bank type, in untabulated analyses, we have used the ratio between non-interest income and total operating income to split the sample between diversified and non-diversified banks (e.g. Stiroh 2004). Diversified banks have a larger fraction of non-interest income as percentage of the total operating income due to activities that generate fee income, trading revenue, and other types of non-interest income than non-diversified ones. We consider the banks that are above (below) the median of annual empirical distribution of the ratio non-interest income/total operating income as diversified (non-diversified). In untabulated results, we find a difference in the response of the two subsamples: diversified banks increase the NSFR after a shock, while non-diversified banks respond to a shock by reducing the NSFR. However, in

Table 11. Euro vs. Non-Euro Banks.

Panel A. NSFR

	Euro		Non-Euro	
	NSFR	NSFR_ADJ	NSFR	NSFR_ADJ
Dependent Variable	(1)	(2)	(3)	(4)
ShockSize	0.0623	−0.2023	−0.5883	−1.0535
	[0.6696]	[0.7382]	[0.6937]	[0.6550]
ShockSize ∗ Crisis MP	0.6416	0.2862	0.4289	0.3583
	[0.5461]	[0.5568]	[1.0851]	[1.0565]
Controls	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes
Adjusted R^2	0.198	0.197	0.075	0.072
N. Obs.	2072	2072	1167	1167

Panel B. Asset – and Liability-side Policies: Euro Banks

Dependent Variable	%ΔAssets (1)	ΔRWA/TA (2)	ΔLoans/TA (3)	ΔCorpLoans/TA (4)	ΔRetailLoans/TA (5)	ΔStLoans/TA (6)	ΔTotSec/TA (7)	ΔDep/TA (8)	ΔStWhFund/TA (9)
ShockSize	0.2447	−0.362	−0.0154	0.1713	−0.0033	0.0536	−0.2146	−0.088	−0.2476
	[0.7618]	[0.3060]	[0.2797]	[0.3813]	[0.2528]	[0.2168]	[0.2523]	[0.3234]	[0.3381]
ShockSize ∗ Crisis MP	0.3962	−0.6938**	−0.5444**	−0.8707**	−0.1832	−0.0816	0.5585***	−0.0563	0.1457
	[0.9133]	[0.3160]	[0.2371]	[0.3444]	[0.2800]	[0.1536]	[0.2154]	[0.3176]	[0.2617]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.160	0.141	0.136	0.164	0.036	0.046	0.161	0.170	0.169
N. Obs.	2233	2106	2228	970	973	1648	2218	2232	1374

Panel C. Asset – and Liability-side Policies: Non-Euro Banks

Dependent Variable	%ΔAssets (1)	ΔRWA/TA (2)	ΔLoans/TA (3)	ΔCorpLoans/TA (4)	ΔRetailLoans/TA (5)	ΔStLoans/TA (6)	ΔTotSec/TA (7)	ΔDep/TA (8)	ΔStWhFund/TA (9)
ShockSize	−2.4677***	0.5837*	0.4598*	−0.2376	0.208	0.312	−0.0763	0.112	−0.0722
	[0.6567]	[0.3439]	[0.2535]	[0.3219]	[0.1858]	[0.4355]	[0.2899]	[0.2254]	[0.3235]
ShockSize ∗ Crisis MP	2.8114***	−0.9532	−1.2251***	−1.4922***	−0.2913	−0.0712	0.5602	−0.6128	0.1736
	[0.8454]	[0.5944]	[0.3944]	[0.5061]	[0.2339]	[0.6278]	[0.4031]	[0.3835]	[0.5160]
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year F. E.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.205	0.118	0.092	0.102	0.091	0.058	0.160	0.109	0.059
N. Obs.	1190	1175	1187	787	787	799	1190	1182	863

This table presents estimates for the NSFR and the adjusted NSFR (Panel A), and asset-side and liability-side (Panel B) policies for subsamples of European and non-European banks for the period 2010–2018. All models include the same explanatory variables as in Tables 3–7 and are estimated with bank and country-year fixed effects. Standard errors are clustered at bank level. ***, **, and * represent statistical significance at 1%, 5%, and 10%, respectively.

periods of expansionary monetary policies the latter effect is reversed. At policy level, there are also some differences. Diversified banks react to shocks by deleveraging and reducing retail loans. They also step up corporate loans, but this effect is attenuated in expansionary monetary policy periods. On the other hand, the behavior of non-diversified banks mirror the one of the full sample.

6. Conclusions

This paper addresses the interplay between capital and liquidity in a double regulatory constraint environment for banks in the European Union under conditions of stress. More specifically, we examine how banks manage their liquidity positions after a negative capital shock when capital and liquidity regulations are combined and during a period characterized by unconventional monetary policy. Faced with a capital shock while trying to comply with both liquidity and capital regulations, banks may employ bank-level policies consistent with deleveraging/de-risking or engage in regulatory arbitrage.

Using a composite measure of liquidity, the NSFR, we determine that, on average, a negative capital shock does not influence bank liquidity at the aggregate level in a double-constraint environment, as DeYoung, Distinguin, and Tarazi (2018) observed for a single-constraint environment. These results hold when the effects of an expansionary monetary policy are included.

Our analysis of the bank-level policies that banks employ in response to capital shocks shows that banks utilize both de-risking and regulatory arbitrage. Contrary to the regulatory aim, banks do not seem to make substantial transitions into safer or long-term funding. Instead, they focus on decreasing the risk of their asset portfolio while using the liquidity buffer to support the same volume of assets. Thus, the regulatory requirements seem to increase banks' exposure to securities and government securities instead of incentivizing them to conduct illiquid corporate lending. We also observe a difference between larger and smaller banks in terms of post-shock behavior. Larger banks shift from corporate lending into securities in response to capital shocks in periods in which central banks heavily rely on unconventional monetary policy tools. In contrast, smaller banks reduce corporate loans while increasing retail loans.

Finally, our analysis of the impact of unconventional expansionary monetary policy on the banks' shock response finds that the aggregated results are stable. Our analysis of bank-level policies reveals that monetary policy impacts parts of the asset and liability sides when banks encounter a capital shock. In particular, we observe that asset-side policies seem to shift from corporate lending to financial assets, including government securities. There is also an effect of bank size, with larger banks changing bank-level policies in response to monetary policies.

Overall, our findings highlight the importance of understanding the implications of a double-constraint environment in the event of a shock. To ensure financial stability, banks can change their asset composition to meet capital and liquidity requirements in a way that is not fully consistent with regulatory intention. The implications of our findings on monetary policy also reveal that banks' compliance with regulation in the event of a capital shock may lead to partial shortages in corporate lending, with banks prioritizing investment in government securities. This is a risk for financial stability and could decrease the supply of capital during periods of frequent shock, an outcome that is not displayed in the aggregated analyses.

Notes

1. The NSFR was set to come into force in the European Union by January 1, 2018, but its implementation was postponed until July 2021.
2. Indeed, most European banks were already complying with the NSFR by 2014 (EBA 2015), and in 2015 both the European Banking Authority (EBA) and the Basel Committee on Banking Supervision (BCBS) started formally monitoring and reporting on the NSFR through quantitative impact studies.
3. See, e.g., Distinguin, Roulet, and Tarazi (2013); Imbierowicz and Rauch (2014); DeYoung and Jang (2016); Walther (2016); Banerjee and Mio (2018); DeYoung, Distinguin, and Tarazi (2018); Naceur, Marton, and Roulet (2018); Roulet (2018); Kara and Ozsoy (2020).
4. We focus on the NSFR because it is designed to improve the matching between long-term assets and short-term liabilities, and thus it should capture the longer-term liquidity strategy of banks.

5. For example, in the final draft of the NSFR disclosure requirements, the Basel Committee on Banking Supervision (BCBS 2015, p. 1) maintains that the objective of the NSFR 'is to reduce funding risk over a longer time horizon by requiring banks to fund their activities with sufficiently stable sources of funding in order to mitigate the risk of future funding stress.'
6. In unreported robustness analysis, we also use the accounting capital ratio, i.e., equity divided by total assets. Results are available from the authors on request.
7. Results for the estimation of the internal capital ratio targets are available from the authors on request.
8. As in DeYoung, Distinguin, and Tarazi (2018), the capital shock relies on observations of events occurring in three consecutive time periods: (1) in period $t-2$ we observe whether the bank's equity capital ratio is below its internal capital ratio target (i.e., the second condition to define the shock); (2) in period $t-1$, we observe whether the bank is hit by a capital ratio shock, computing a continuous variable that measures the magnitude of the decline in the bank's equity capital; and (3) in period t we observe the change in the bank's liquidity position.
9. We do not rely on regulatory capital ratios, because in our sample there are just 38 occurrences of banks with capital ratios below 10.5%, and only four with capital ratios below 8%.
10. In unreported analysis, we use a binary variable to capture the shock. The results are qualitatively similar to those reported in the tables here.
11. Unlike DeYoung, Distinguin, and Tarazi (2018), we do not include the lagged mean of the dependent variable. To absorb trends in banks' financial conditions, we would have to compute this mean at country level. However, our model already includes country × year fixed effects, which renders the inclusion of this variable redundant.
12. While this evolution contrasts with the consolidation trend that has dominated the banking industry since the global financial crisis, it can be explained in terms of the improved coverage of S&P Capital IQ Pro for the most recent period.
13. The NSFR as reported is available only for the period 2016–2018 and for a limited number of banks.
14. The average values of domestic and non-domestic loans do not sum to 64% because values for domestic and non-domestic loans are not available for all observations.
15. Some of the measures are main refinancing operations with full allotment (at fixed rate), different long-term refinancing operations with different long-term maturity periods (3, 6 months, 1, 3 years, etc.), and the purchases of securities by the ECB/Eurosystem, such as the Security Market Program or Covered Bonds Purchase Program.
16. In unreported analyses, following Peydró, Polo, and Sette (2021), we also use a second proxy for the monetary conditions: the Taylor (2009) residuals measure obtained by regressing EONIA (the overnight interest rate for the EURO area) on change in a country's GDP and its consumer price index. Peydró, Polo, and Sette (2021) used the Taylor-rule residuals as a proxy for the monetary policy in 'normal' times.
17. In untabulated results, we find that similar patterns hold when we use deposits in proportion to total loans.
18. For instance, the 2010–2014 period includes the sovereign debt crisis that followed the great financial crisis of 2008–2009. It is characterized by credit-easing measures like the Securities Markets Program (2010–2012), the Outright Monetary Transaction plan (from 2012), the Covered Bond Purchase Program (2011–2012), and subsidized lending to banks (the bulk of longer-term refinancing operations [LTRO] and the first tranche of Targeted LTRO in 2014). Together with the continuation of some of the previous measures, the 2015–2018 period saw the start of the quantitative easing program (Public Sector Purchase Program from 2015 onwards), new and more targeted credit-easing policies like the Asset Backed Securities Purchase Program (late 2014 onwards), and the Corporate Sector Purchase Program (from 2016).
19. Since the start of some of these programs take place in 2014, we assess also the time period by assigning 2014 to the early period rather than to the late period in an unreported analysis.. Splitting the sample between 2010–2013 (early period) and 2014–2018 does not significantly alter our main results.
20. Results for the significant credit institutions subsample are discussed in the text but are not tabulated. Tables are available from the authors on request.
21. See https://www.bankingsupervision.europa.eu/banking/list/criteria/html/index.en.html.
22. Results are available from the authors on request.
23. Our sample includes only 7 banks for which investment banking is considered among the primary industries according to S&P Capital IQ Pro. Given their limited number and the fact that they also have commercial banking businesses, these 7 banks are included in the commercial banks sample (19 observations at bank-year level). Results are unaffected if we remove them from the commercial bank sample.
24. The results of the analysis based on bank type are discussed in the text but are not tabulated. Tables are available from the authors on request.
25. Savings/thrift banks are not necessarily small banks; the correlation between small banks and savings/thrift banks is negligible (-0.01).

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Appendix: Variable Definitions

This appendix reports the definitions of all the variables used in the analysis. ΔVariable is the difference of the variable between time *t* and *t−1*.

Variable	Definition
Tier12/RWA	Total capital ratio/100 where the total capital ratio is (Tier 1 and 2 capital)/Risk-weighted assets (Source: S&*P* Capital IQ Pro)
NSFR	ASF/RSF where ASF is (1∗max(total_equity,0) + 1∗total_subordinated_debt1 + 1∗senior_debt_obligations + 1∗hybrid_securities + 0.95∗(total_deposits-other_deposits1) + 0.5∗other_deposits1 + 0∗total_deposits_from_banks1 + 0∗other_financial_liabilities1)and RSF is (0.5∗net_loans_to_banks1 + 1∗fixed_assets1 + 1∗investment_in_partnerships1 + 1∗total_intangible_assets1 + 1∗(gross_customer_loans-net_customer_loans1) + 1∗other_assets1 + 0.85∗net_customer_loans + 0.5∗max((total_securities1-debt issued or guar by national or supranational govt1-investment_in_partnerships),0) + 0.05∗ debt issued or guar by national or supranational govt1 + 0∗cash_and_bal_with_cent_banks1) (Source: S&*P* Capital IQ Pro)
NSFR_adj	NSFR ratio adjusted for equity. (Source: S&*P* Capital IQ Pro)
Assets (ln)	Ln (Total assets) (Source: S&*P* Capital IQ Pro)
%ΔASSETS	Annual percentage change in total assets (Source: S&*P* Capital IQ Pro)
Loans/TA	Total net loans/Total assets (Source: S&*P* Capital IQ Pro)
TotSec/TA	Total securities/Total assets (Source: S&*P* Capital IQ Pro)
GovSec/TA	Debt issued by national or supranational governments/Total assets (Source: S&*P* Capital IQ Pro)
CorpLoans/TA	Corporate loans/Total assets (Source: S&*P* Capital IQ Pro)
RetailLoans/TA	Retail loans/Total assets (Source: S&*P* Capital IQ Pro)
StLoans	Sum of loans with maturity of less than 3 months and from 3–12 months/Total assets (Source: S&*P* Capital IQ Pro)
MtLoans	Loans with maturity from 1–5 years/Total assets (Source: S&*P* Capital IQ Pro)
LtLoans	Loans with maturity over 5 years/Total assets (Source: S&*P* Capital IQ Pro)
DomLoans/TA	Domestic loans/Total assets (Source: S&*P* Capital IQ Pro)
NonDomLoans/TA	Non-domestic loans/Total assets (Source: S&*P* Capital IQ Pro)
Listed dummy	Binary variable that takes value 1 if ownership status = 'listed'; otherwise, 0 (Source: S&*P* Capital IQ Pro)
SDROA	Standard deviation of ROA over preceding 5 years (Source: S&*P* Capital IQ Pro)
Deposits/TA	Total deposits/Total assets (Source: S&*P* Capital IQ Pro)
RetailDep/TA	Retail deposits/Total assets (Source: S&*P* Capital IQ Pro)
CorpDep/TA	Corporate deposits/Total assets (Source: S&*P* Capital IQ Pro)
StWhFund/TA	Wholesale funding with maturity of less than 1 year/Total assets (Source: S&*P* Capital IQ Pro)
RWA/TA	RWA/TA (Source: S&*P* Capital IQ Pro)
MP	(Total assets of the CB balance sheet – Average total assets of the CB balance sheet) divided by the standard deviation of the nominal GDP of the reference country (Source: ECB and national CBs)
Below	Equals 1 if Tier12/RWA < Tier12/RWA_target (from the partial adjustment model)
ShockSize	The magnitude of the decline in the bank's equity capital when the following three conditions are satisfied: (1) there is a decrease in the equity capital ratio (ΔK_(i,t-1) < 0); (2) the bank is already operating below its internal capital ratio target; and (3) the decrease leads to an even larger deviation from the bank's internal target